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Bassendean and Spearwood Dunes: their geomorphology, stratigraphy and soils as a basis for habitats of *Banksia* woodlands

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Introduction

Banksia woodlands and allied plant associations inhabit the extensive sandy soils of the Bassendean and Spearwood dune systems of the Swan Coastal Plain of SW Australia. These dune systems also have formed the basis for identifying vegetation associations in relationship to landscape (Heddle *et al* 1980, Cresswell & Bridgewater 1985). However, to date, there has not been a systematic description of the dunes in terms of their landforms, stratigraphy, soils, inter-relationships and age structure specifically for the purposes of landscape ecology, ie for delineation of vegetation habitats (cf Semeniuk *et al* 1989). This paper reviews the physical features of the Bassendean and Spearwood dunes as habitats for *Banksia* woodlands, describes some of the smaller scale variability of the dune systems as a basis for identifying potential habitats for vegetation, and suggests guidelines for identifying habitats.

Description of geomorphology, stratigraphy and soils

The Swan Coastal Plain is subdivided into 5 regional scale geomorphic units which are in narrow belts oriented north-south (McArthur & Bettenay 1960; Fig. 1). These units are: Ridge Hill Shelf - a landform underlain by Pleistocene laterite and sand; Pinjarra Plain - Pleistocene to Holocene fluvial landforms and sediments; Bassendean Dunes - undulating hills and degraded Pleistocene aeolian landforms underlain by yellow and white quartz sand; Spearwood Dunes - shallow to deep yellow quartz sand overlying shore-parallel ridges and depressions of Pleistocene aeolianite limestone (locally, there are ridges of yellow sand with little or no underlying limestone); and Quindalup Dunes - Holocene calcareous coastal dunes.

The Bassendean and Spearwood dunes dominate the longitudinally central part of the Swan Coastal Plain. Bassendean Dunes exhibit high relief (up to 80m above AHD) in the northern Swan Coastal Plain, and low relief in the south. Locally in both settings linear ridges and mounds of sand have relative relief of 20-40m. In contrast, the Spearwood Dunes have a relief of c50-80m both in the northern and southern Swan Coastal Plain.

Geomorphologically, the Bassendean and Spearwood dunes can be subivided into drylands and wetlands. Drylands can include dunes and interdunes. Dunes can be progressively subdivided into high dunes and low dunes, then into dune crests, dune flanks, and then into north flanks and south flanks. Similarly, interdunes can be systematically divided into thick sand sheets and thin sand sheets, then into sand sheets with a deep water table and sand sheets with a shallow water table. Alternatively, the dunes may be divided on geometry into simple linear dunes, composite linear dunes, sinuous linear dunes, star dunes, dome dunes, parabolic dunes, barchan dunes, and lunette dunes (Fig.1). Wetlands can be classified according to CASemeniuk (1987).

Stratigraphically, Bassendean Sand is equivalent to sands of the Bassendean Dunes, and Tamala Limestone is equivalent to the limestone portion of the Spearwood Dunes. The Tamala Limestone and Bassendean Sand interfinger along unconformity interfaces, the Bassendean Dunes may contain isolated lenses of limestone, and the yellow sands of the Bassendean and Spearwood dunes can be traced into each other (Fig.1). To date, the bulk of the yellow quartz sand

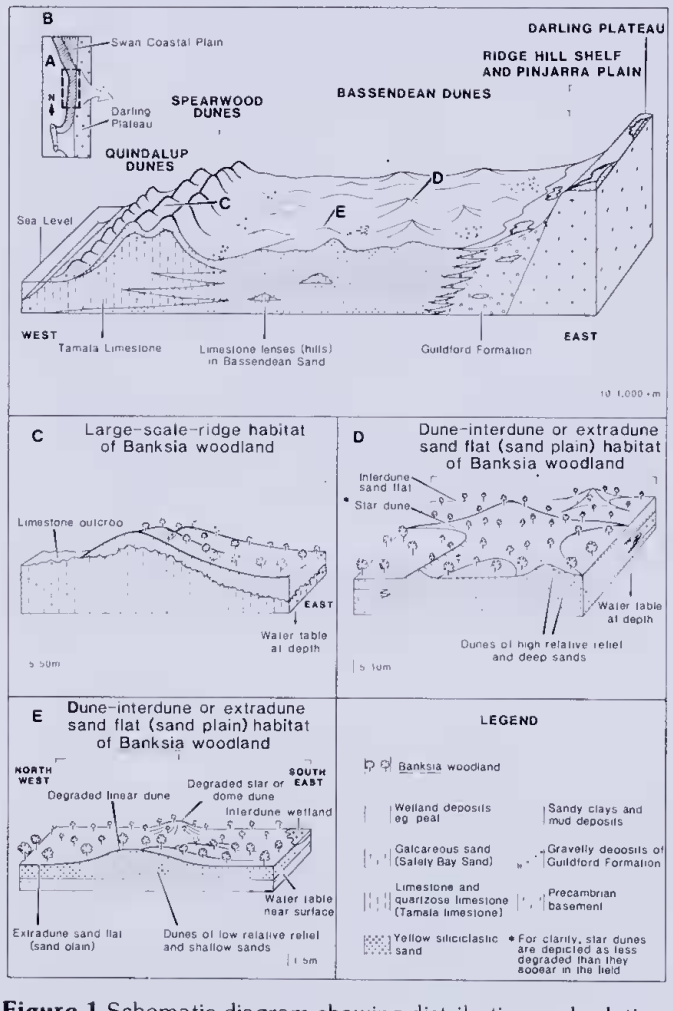

Figure 1 Schematic diagram showing distribution and relationships of the geomorphic units across the Swan Coastal Plain, the relationships between the underlying stratigraphic units, and details of the medium to small scale geomorphology of the Bassendean and Spearwood dunes as a basis for habitats of the *Banksia* woodlands. For details see Semeniuk & Glassford (1988) and Glassford & Semeniuk (1989).

overlying the Tamala Limestone has not been formally recognised as a separate formation, except in local areas (Glassford & Semeniuk 1989). Lithologically, yellow sands of the Bassendean and Spearwood dunes consist of quartz, felspar, heavy minerals and kaolin. A goethite-stained coating of silt-clay sized kaolin and quartz on the grains imparts the yellow colouration (Glassford & Semeniuk 1989).

Information on the soils is difficult to review because the soil units have been inconsistently and imprecisely described, and inconsistently mapped; eg compare the definition of soil associations, series and phases (Bates & Jackson 1987; and discussion in Conacher & Dalrymple 1977), with the use of these terms in the local literature, and similarly, compare the various descriptions in map legends and texts of soil units which appear to largely overlap or be co-incident. Also, compare the different designations of landform-soil units near Mandurah (McArthur & Bettenay 1960, Churchward & McArthur 1980, McArthur & Bartle 1980), and the inconsistent location of the boundary of the Bassendean and Spearwood dunes in various maps. The definitions of the soil units do not differentiate between a stratigraphy resulting from complex and multiple pedogenic alteration, and the more simple, shallow products of pedogenesis superimposed on a complex primary stratigraphy, particularly where landforms are degraded, ie tending towards planation. Furthermore, primary sedimentary features and secondary alteration features frequently are not identified or separated. Further discussion of these aspects of landform-soil units of the Swan Coastal Plain are presented in Semeniuk (1989).

Soil and landform-soil units (Churchward & McArthur 1980) are the features most used by phyto-sociologists to correlate vegetation with physical setting, and so we summarise information on the soil units, without implication that we accept these subdivisions. Soils of the Bassendean Dunes are subdivided into Bassendean and Southern River soil associations. Bassendean soils occur on dunes and interdune sand sheets, and comprise deep grey sands with humic or ferruginous layers. Southern River soils are similar to Bassendean soils, but differ in the occurrence of sandy clay, clay and swamp deposits. Soils of the Spearwood Dunes are subdivided into Karrakatta and Cottesloe soil associations. Karrakatta soils comprise deep yellow sands over limestone, and are divided into yellow and grey soil phases. Cottesloe soils consist of exposed limestone, or shallow brown sands over limestone.

The deeper stratigraphy underlying the Bassendean and Spearwood dunes, rather than the actual surficial soils, has been the basis for subdividing soil units. Separation of soil types on the Spearwood Dunes has a genetic basis, ie yellow sand is assumed to be a residual soil derived by leaching from limestone, and depth of yellow sand is used as an index of soil development. If yellow sand overlying limestone has not formed by leaching in situ, the actual soils within the Spearwood dunes are humic and bioturbated surface alterations of a parent yellow sand of variable thickness (Glassford & Semeniuk 1989). However, even if it is assumed that yellow sands formed by in situ leaching, then these sands, which are mostly Pleistocene, are relict. Therefore, the parent material for present day soils is not limestone, but a relict, Pleistocene yellow sand. Accordingly, where limestone is covered by yellow sand, the soils of the Spearwood Dunes should be classed as humic and bioturbated quartz sand on a parent yellow sand. Where limestone is nearly exposed at the surface, the soils of the Spearwood Dunes should be classed as humic sands and rendzinas on limestone. Similarly, soils of the Bassendean Dunes have been separated on the basis of the stratigraphy underlying the dunes and interdunes, rather than on the actual surficial soils.

Vegetation habitats

The *Banksia* woodlands inhabit a dry, nutrient-poor, quartz sand terrain. In detail, other physico-chemical features may be habitat/vegetation determinants, particularly at the small scale (cf Semeniuk *et al* 1989). The following aspects can determine environmental conditions, and hence variations in habitats and understorey assemblages in the *Banksia* woodlands: location within dune type or interdune; depth to water table; aspect; organic soil development; kaolin content; Fe-mineral content; colour; thickness of bleached soil; moisture content in the vadose zone; and subsurface stratigraphic or pedogenic features, particularly for their influence on hydrology, and retention of water and nutrients. Some vegetation studies already have identified habitats, to various levels of detail, in terms of some of these edaphic features. Havel (1968) correlated vegetation types to some detailed edaphic information such as aspect, soil depth, soil moisture etc. Heddle *et al* (1980) recognized landform and soil as determinants of vegetation floristics and structure, but did not proceed beyond correlating broad associations to the large scale geomorphic and soil systems of McArthur and Bettenay (1960) and Churchward & McArthur (1980). Cresswell and Bridgewater (1985) related vegetation associations within the Bassendean and Spearwood dunes to location on dune crests (tops), slopes, swales, an approach which effectively identifies location of habitat within dune terrain. However, we consider that to adequately address the variability of floristics in the *Banksia* woodlands of the Bassendean and Spearwood dunes, that phyto-sociologic studies should be undertaken in conjunction with a determination of the physical features listed above.

It should be apparent from the above, that the geomorphology, stratigraphy, and soils of the Bassendean and Spearwood dunes, in our opinion, have not been documented in sufficient detail, using modern systematic approaches, at the full range of large to fine scales. However, the development of an adequate descriptive framework of these physical features of the dune terrains should be an essential first stage requirement both for purposes of landscape ecological studies and for the identification of resource variability within *Banksia* woodland systems.

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